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Title: Characterization of Delayed-Neutron and Delayed-Gamma Pyroprocessing Emission Signatures Using MCNP6

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Characterization of Delayed-Neutron and Delayed-Gamma Pyroprocessing Emission Signatures Using MCNP6
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A computational non-destructive safeguards study has been conducted using the MCNP6[1] radiation-transport code to examine delayed-neutron (DN) current and delayed-gamma (DG) activity ratio (AR) signatures for a conceptual electrorefining and pyroprocessing (EP) model. Spent-fuel (SNF) inventories were prepared using MCNP6 burnup calculations for a generic Westinghouse fuel assembly[2] with 3% and 5% ^{235}U enrichments; 20-, 30-, 40-, and 50-GWd/MTU burnups; and 3-, 5-, 10-, 20-, and 30-year cooling times to facilitate parametric evaluations. The electrorefining model was patterned after the INL Mark-IV electrorefiner (ER),[3] and treats the distribution of active metals, noble metals, lanthanides, uranium, and TRUs following fuel dissolution and transport to the molten salt eutectic, liquid cadmium cathode (LCC), and cathode mandrel. Signatures have been assessed before and after electrorefining. DG ARs for ^{134}Cs/^{137}Cs, ^{134}Cs/^{154}Eu, and ^{154}Eu/^{137}Cs were developed, and preliminary assessment of new DG ARs that may be better suited for pyroprocessing safeguards was done. Figure 1 shows calculated DN and DG fluxes for 3% enrichment, 20 GWd/MTU burnup, 3 year cooling before electrorefining, with SNF in the ER, and after electrorefining, with material assignment to processing units. Our work suggests that DN and DG markers can be useful for EP forensic analysis

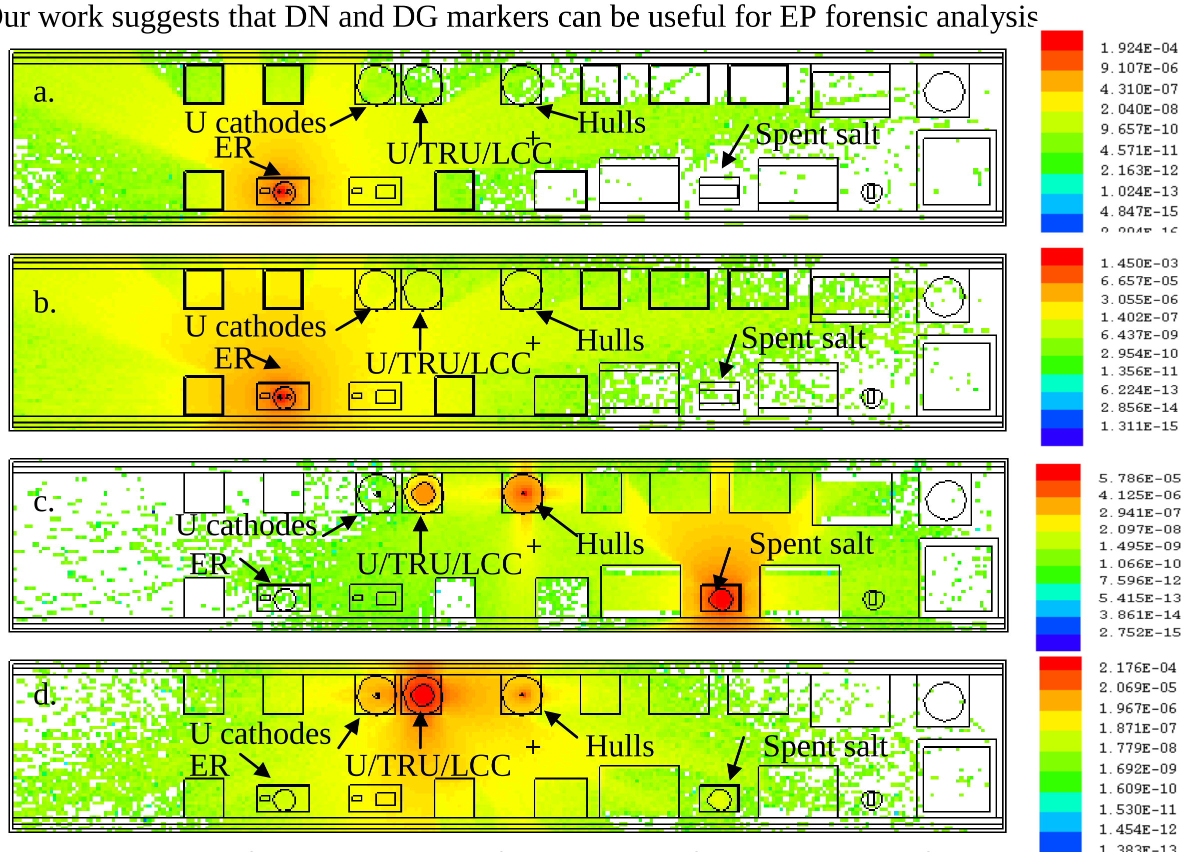

Figure 1. MCNP6 flux mesh tallies before (a,b) and after (c,d) electrorefining. a,c: Photon (photons/cm^2-s). b,d: Neutron (neutrons/cm^2-s).

[1] Goorley, T., James, M., Booth, T., Brown, F., Bull, J., Cox, L.J., Durkee, J., Elson, J., Fensin, M., Forster, R.A., Hendricks, J., Hughes, H.G., Johns, R., Kiedrowski, B., Martz, R., Mashnik,

S., McKinney, G., Pelowitz, D., Prael, R., Sweezy, J., Waters, L., Wilcox, T., and Zukaitis, T., 2012. “Initial MCNP6 Release Overview,” *J. Nuclear Technology*, to appear December 2012.
[2] Organisation for Economic Co-operation and Development-Nuclear Energy Agency (2012), website http://www.oecd-nea.org/science/wpncs/buc/status.html, Benchmark Reports link Benchmark IV-B document http://www.oecd-nea.org/science/wpncs/buc/specifications/PhaseIVB_report.pdf, last accessed September 19, 2012.
[3] Li, S.X., October 2002. “Anodic Process of Electrorefining Spent Nuclear Fuel in Molten LiCl-KCl-UCl3/Cd System,” Idaho National Laboratory report INL/CON-05-00305 preprint.